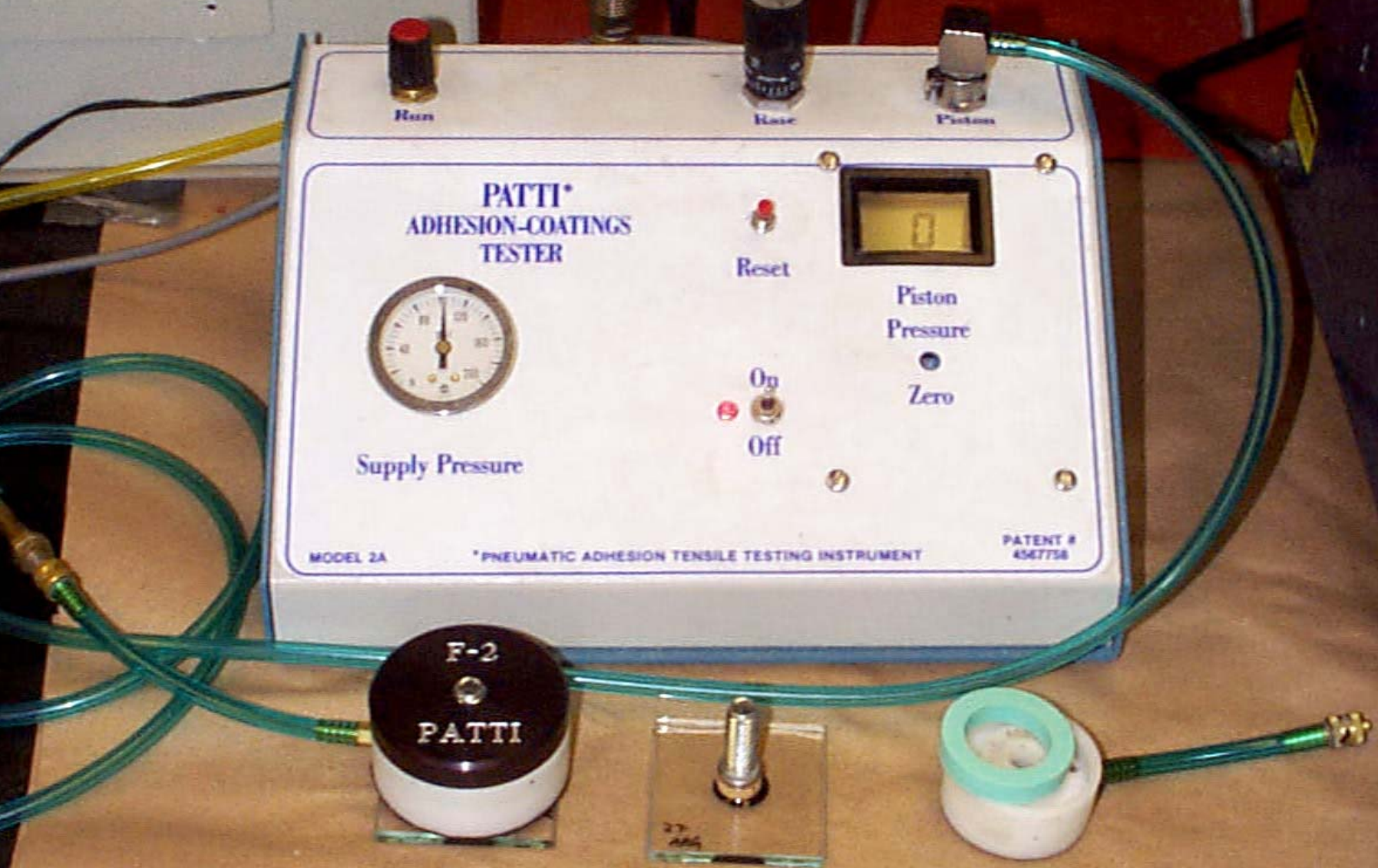




# Moisture Sensitivity

Utility of the Pull-Off Test

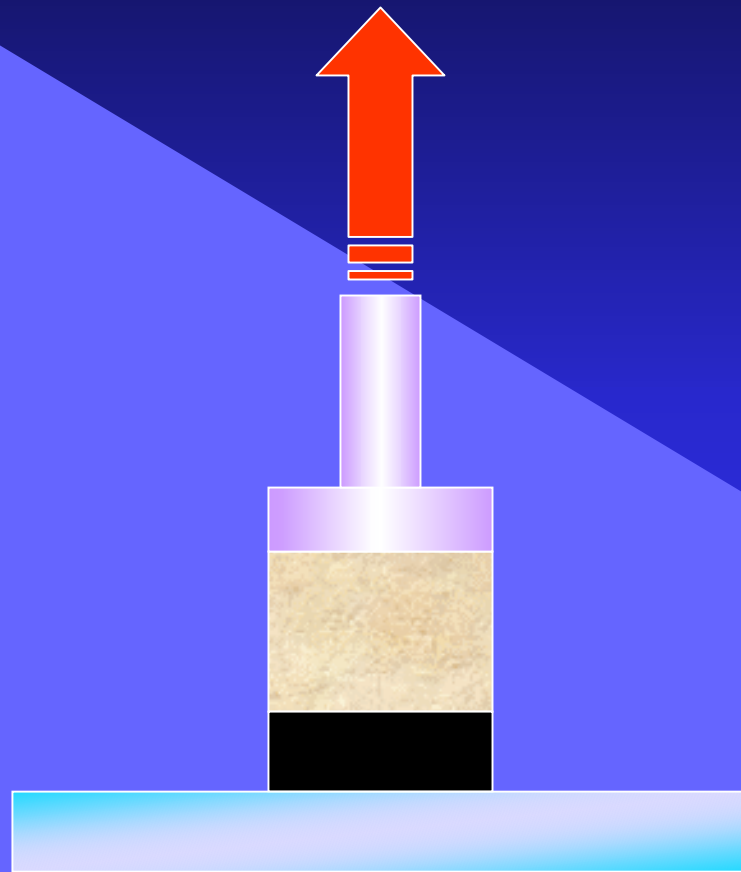
# Pneumatic Pull-Off Test



# Objectives

- Develop reliable and rapid method for evaluating the moisture susceptibility of neat and modified asphalt binders.
- Gain insight into the mechanisms by which water adversely affects asphalt pavements.
- Investigate aggregate systems that may contribute to adhesive failures, i.e., presence of surface active clays.

# Pneumatic Pull-Off Test

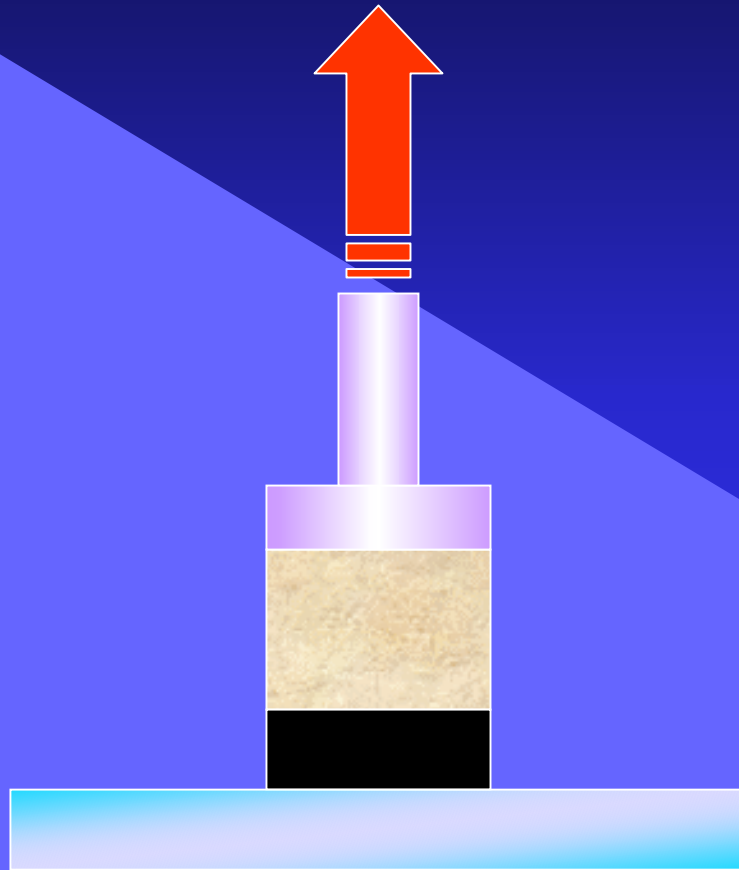


# Pneumatic Pull-Off Test

## Cohesive Failure



# Pneumatic Pull-Off Test



# Pneumatic Pull-Off Test Adhesive Failure

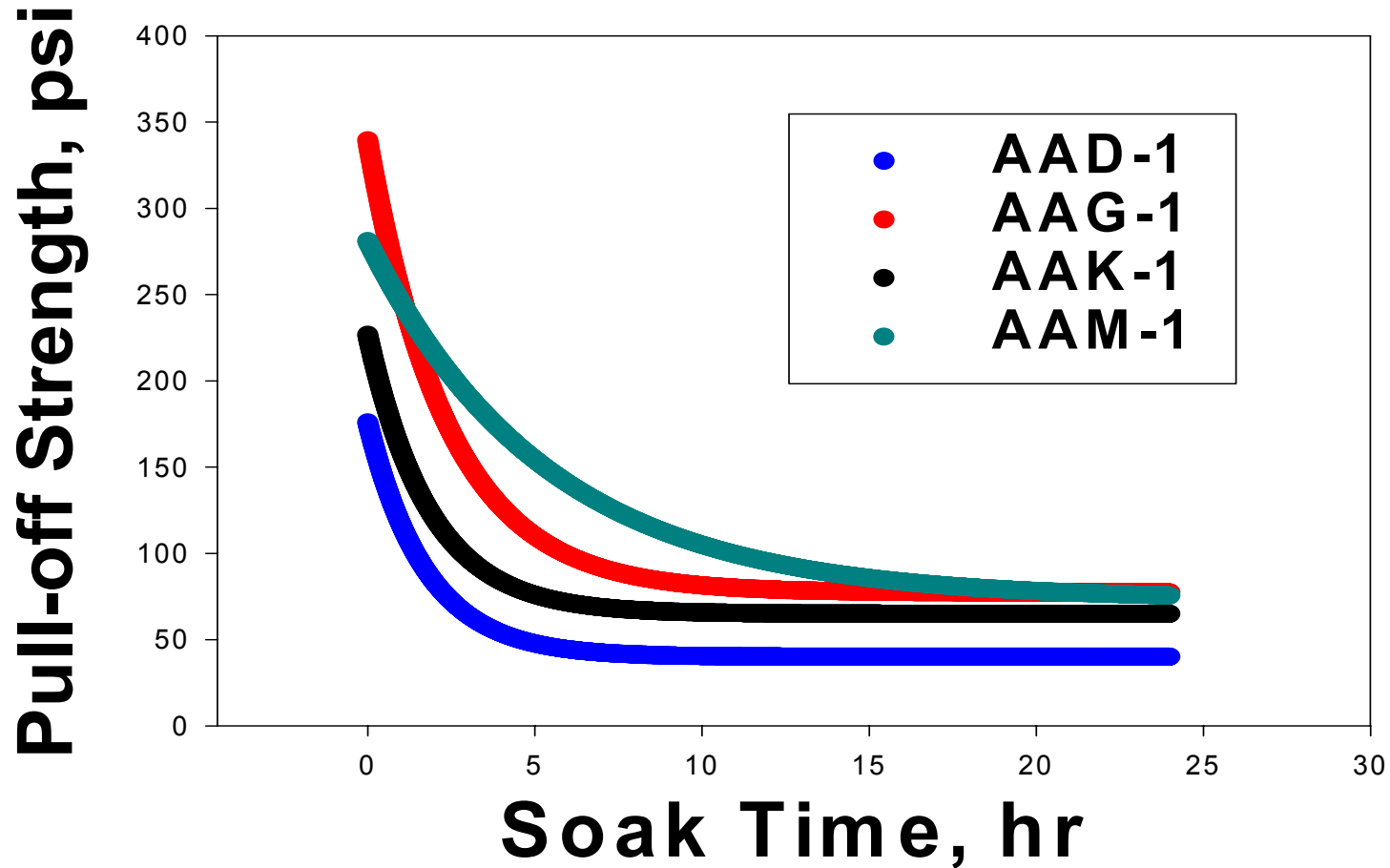




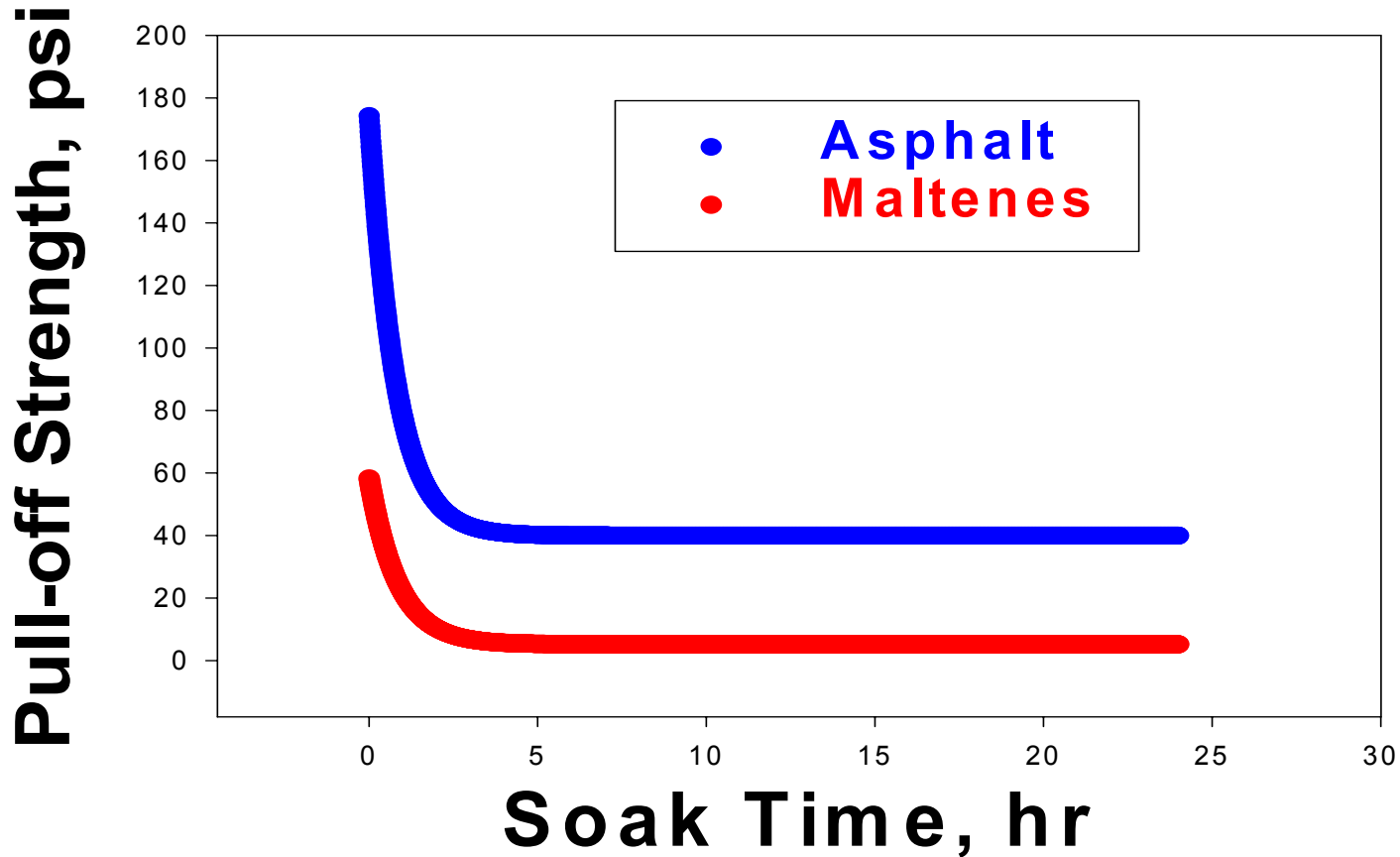
# Test Parameters

■ Glass Beads	1 wt.%
■ Film Thickness	200 microns
■ Loading Rate	65.7 kPa/sec
■ Test Temperature	25°C
■ Soak Temperature	25°C
■ Soak Times	0 - 24 hr

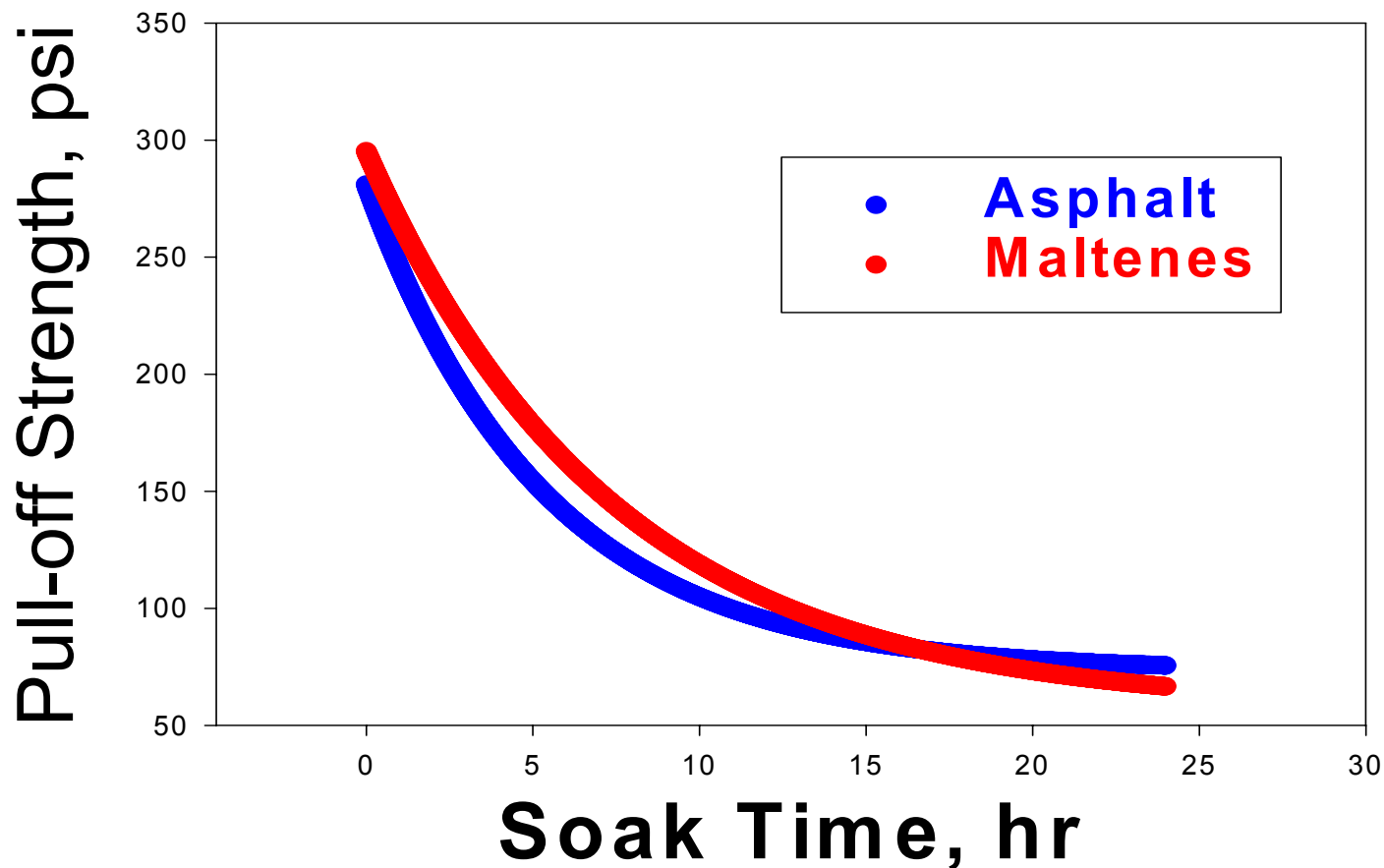
# Effect of Soak Time on SHRP Core Asphalts

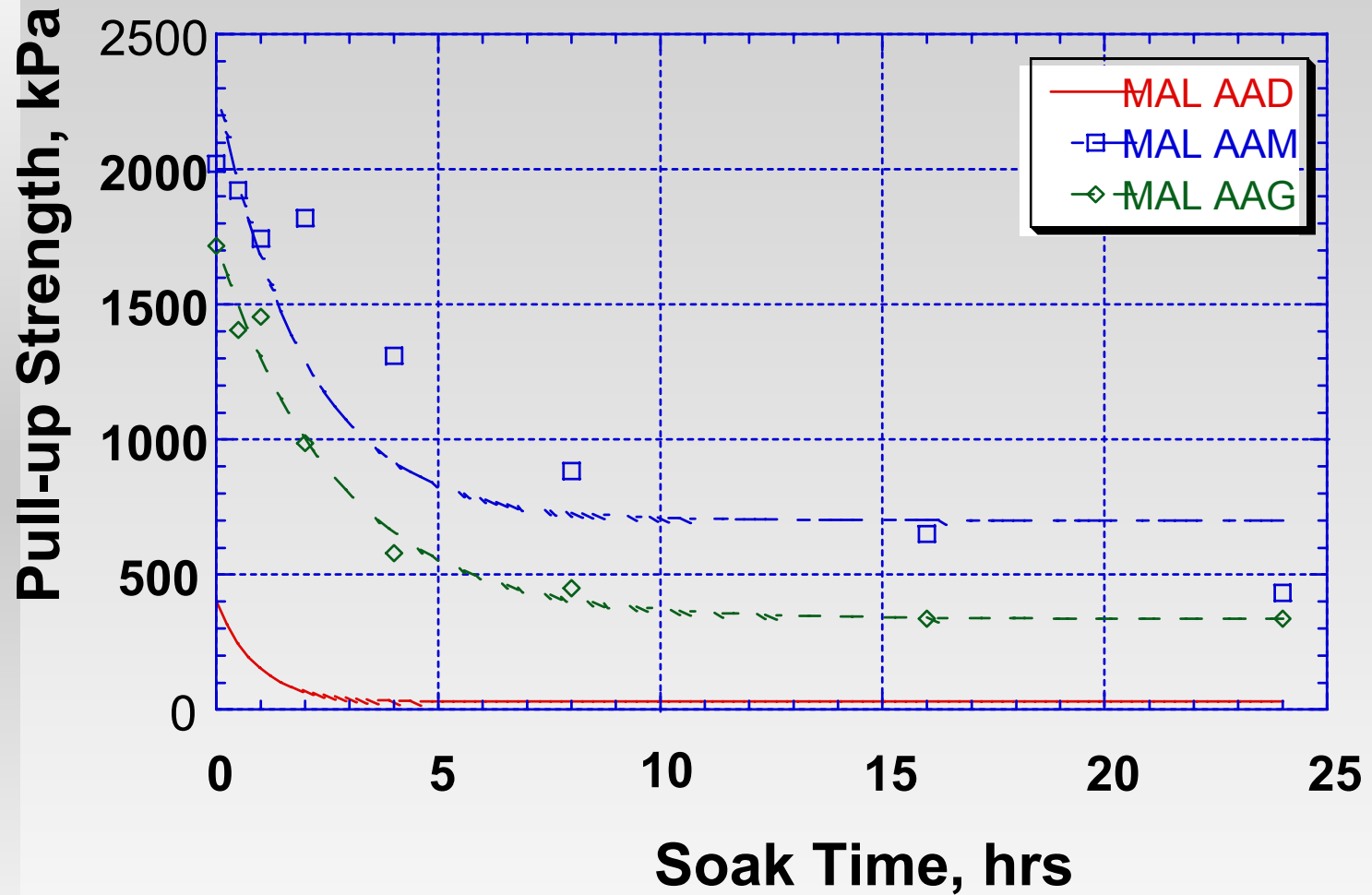


# Effect of Soak Time on AAD-1 Asphalt and Maltenes



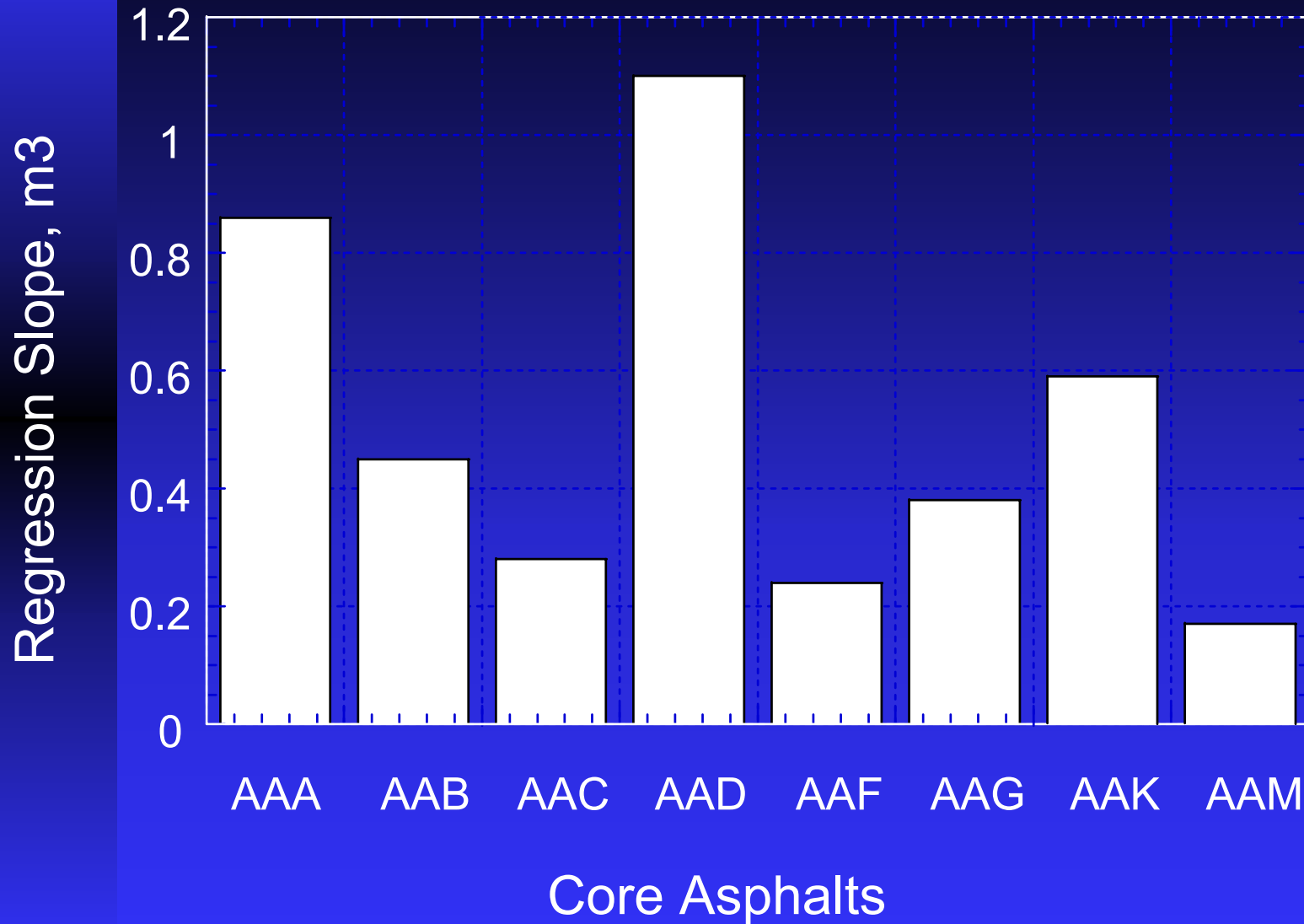
# Effect of Soak Time on AAM-1 Asphalts and Maltenes



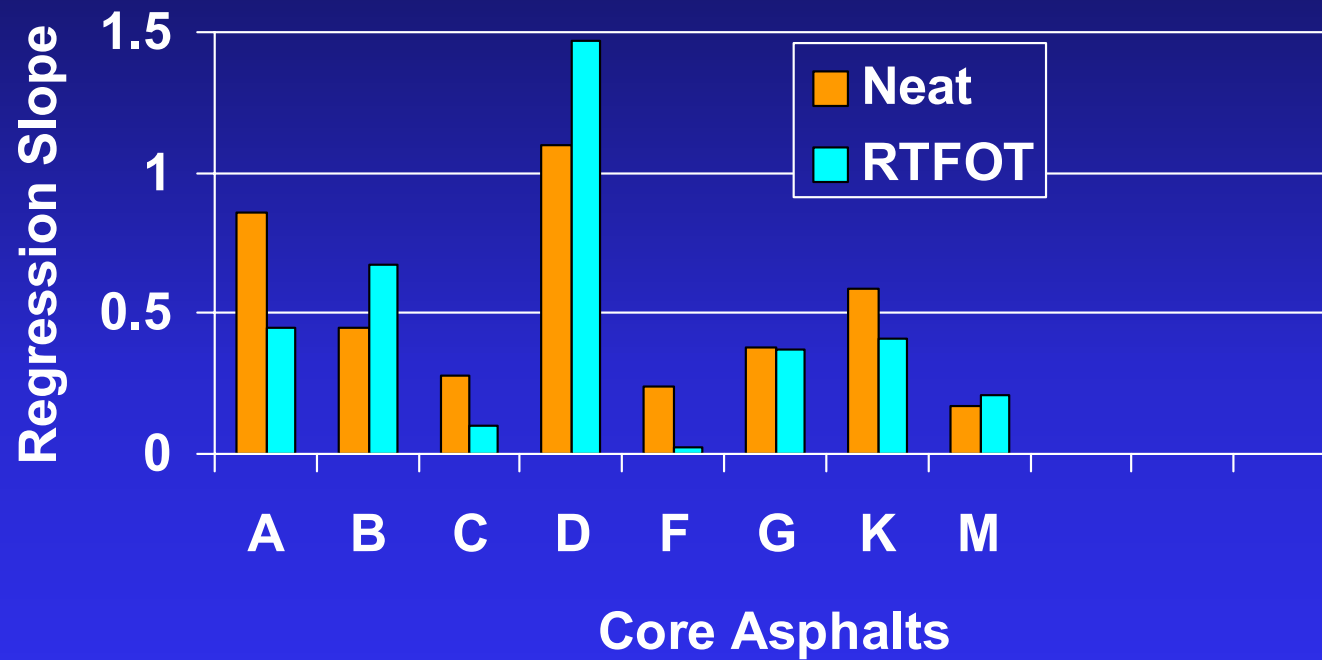


**Effect of Soak Time on Pull-off Strength of Maltenes**

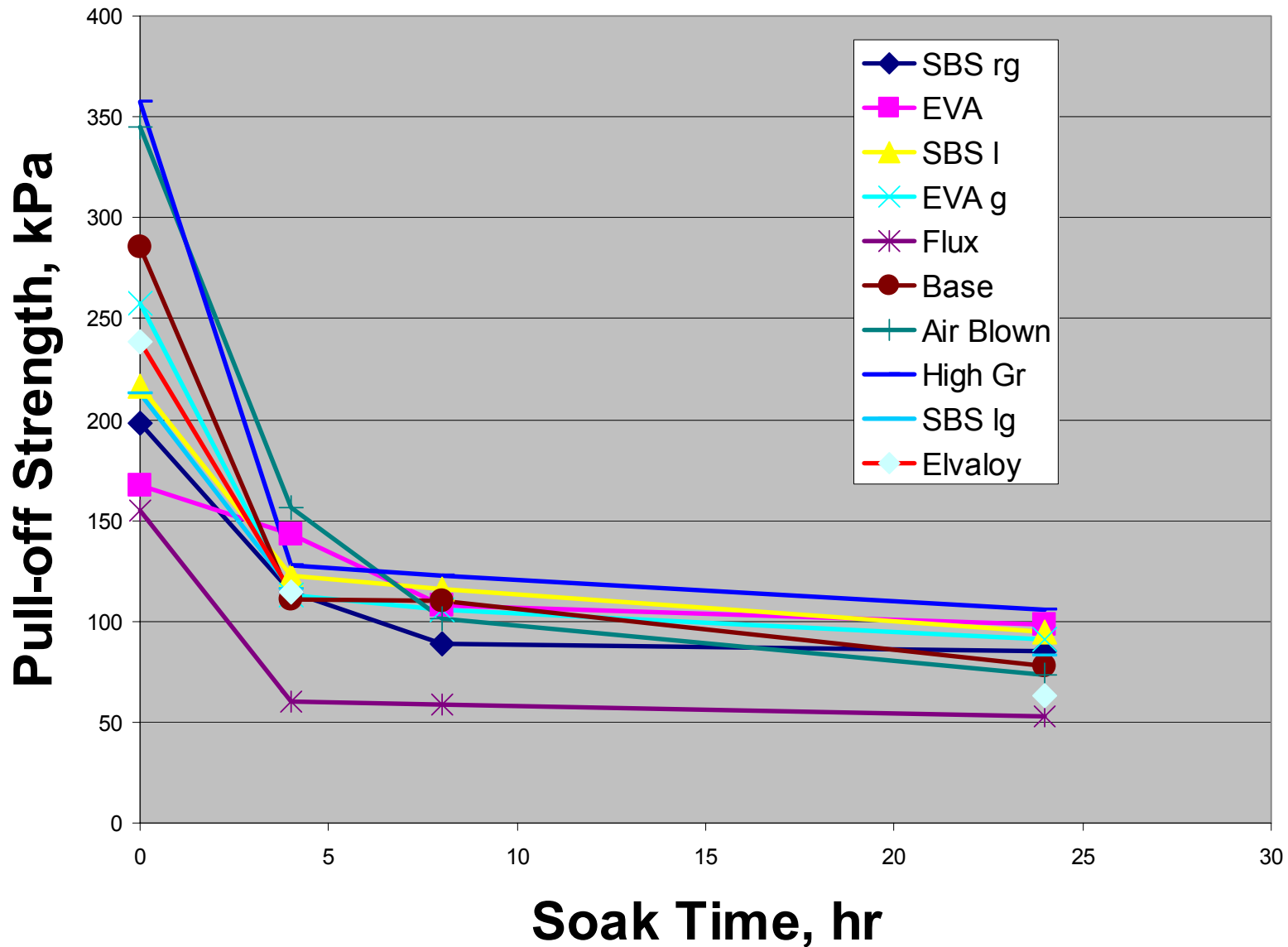
# Regression Slopes for Unaged SHRP Core Asphalts



## Regression Slope for Core Asphalts

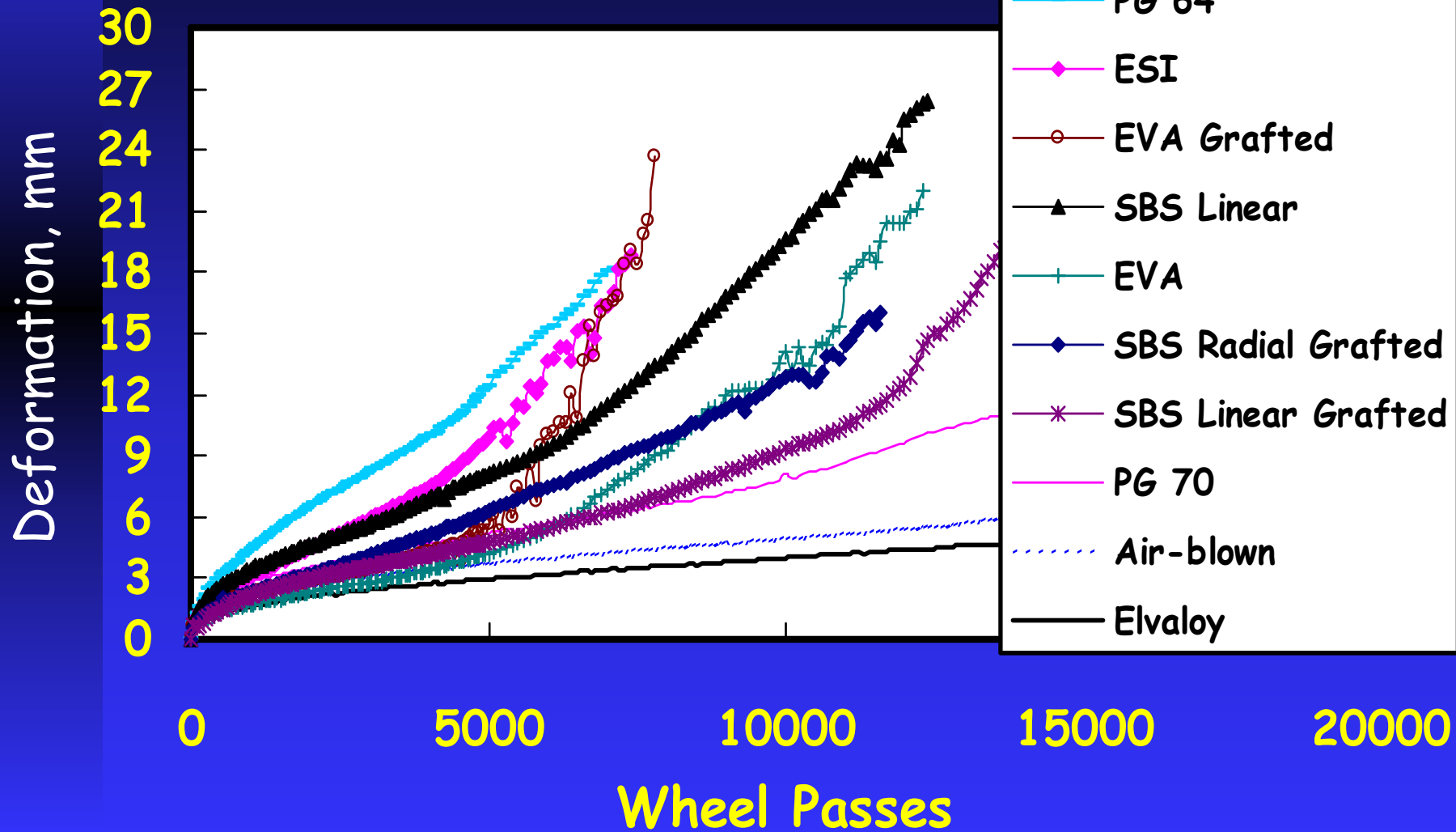


# Pneumatic Adhesion Test





# Deformation vs. Hamburg WTD wheel passes, 58 °C.



# Findings

- Stiffer binders offer greater resistance to moisture susceptibility.
- Oxidation tends to improve this resistance.
- But stiffening attributed to excessive aging in the field may be detrimental. Pull-off test may not be able to identify this mode of distress.

# Findings

- Asphalts containing stiffer / more viscous maltenes are less moisture sensitive.
- Mode of modification can significantly affect the cohesive and adhesive strength of the binder.

# Ongoing Studies

- Mastic Testing with Pull-Off Tester
  - ◆ 6% and 31% loadings of -200 mesh agg.
- Evaluation of Clays
- Evaluation of Lime Useage

# Effect of Clays

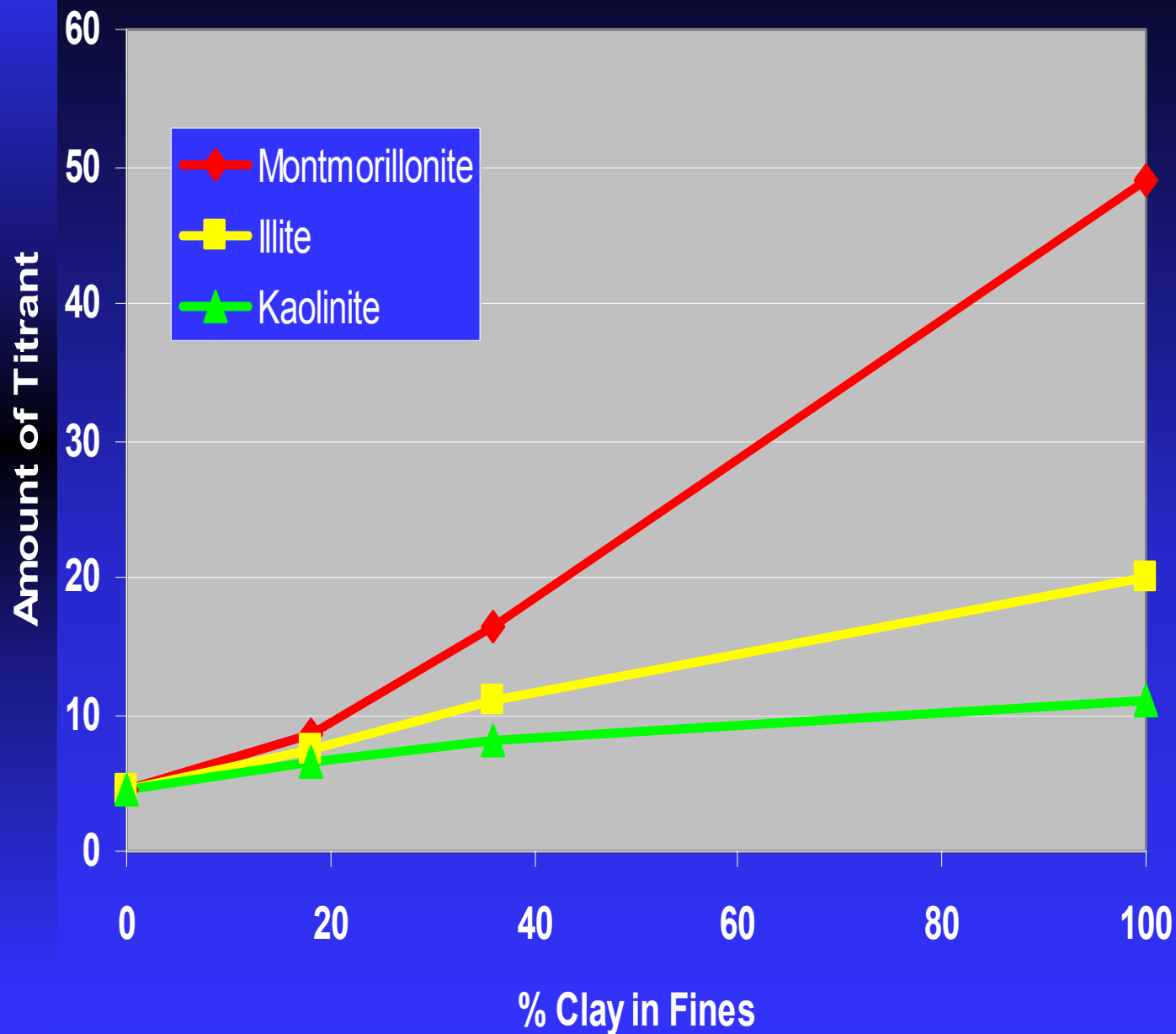
## ■ Key Findings

- ◆ Not all clays are alike
- ◆ Mixes containing montmorillonites are not likely to be corrected by antistrips
- ◆ Hamburg validated the Pull-Off Test results of clay mastics

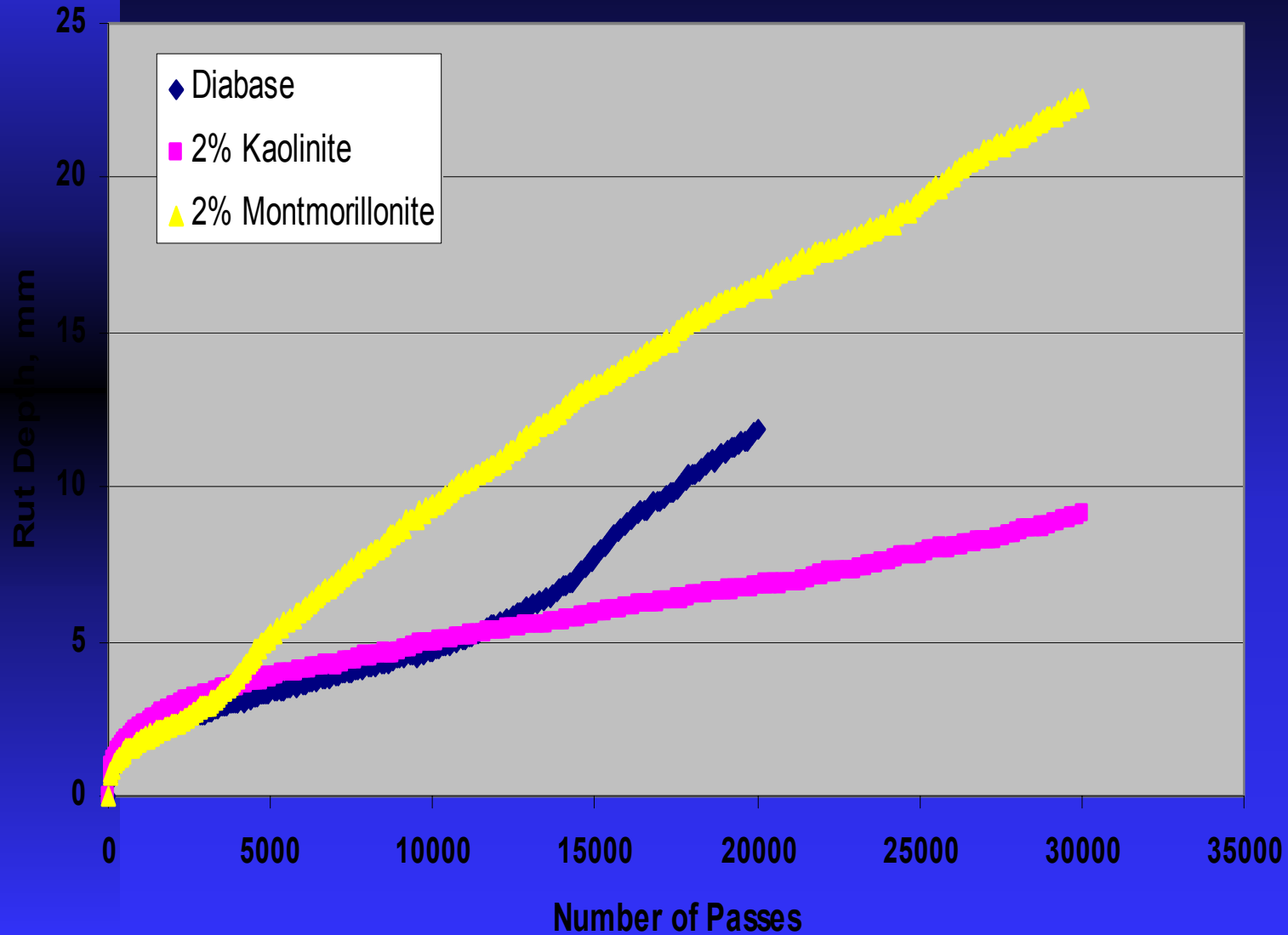
## ■ Recommendation

- ◆ Use Methylene Blue Test!!!!!!!!!!

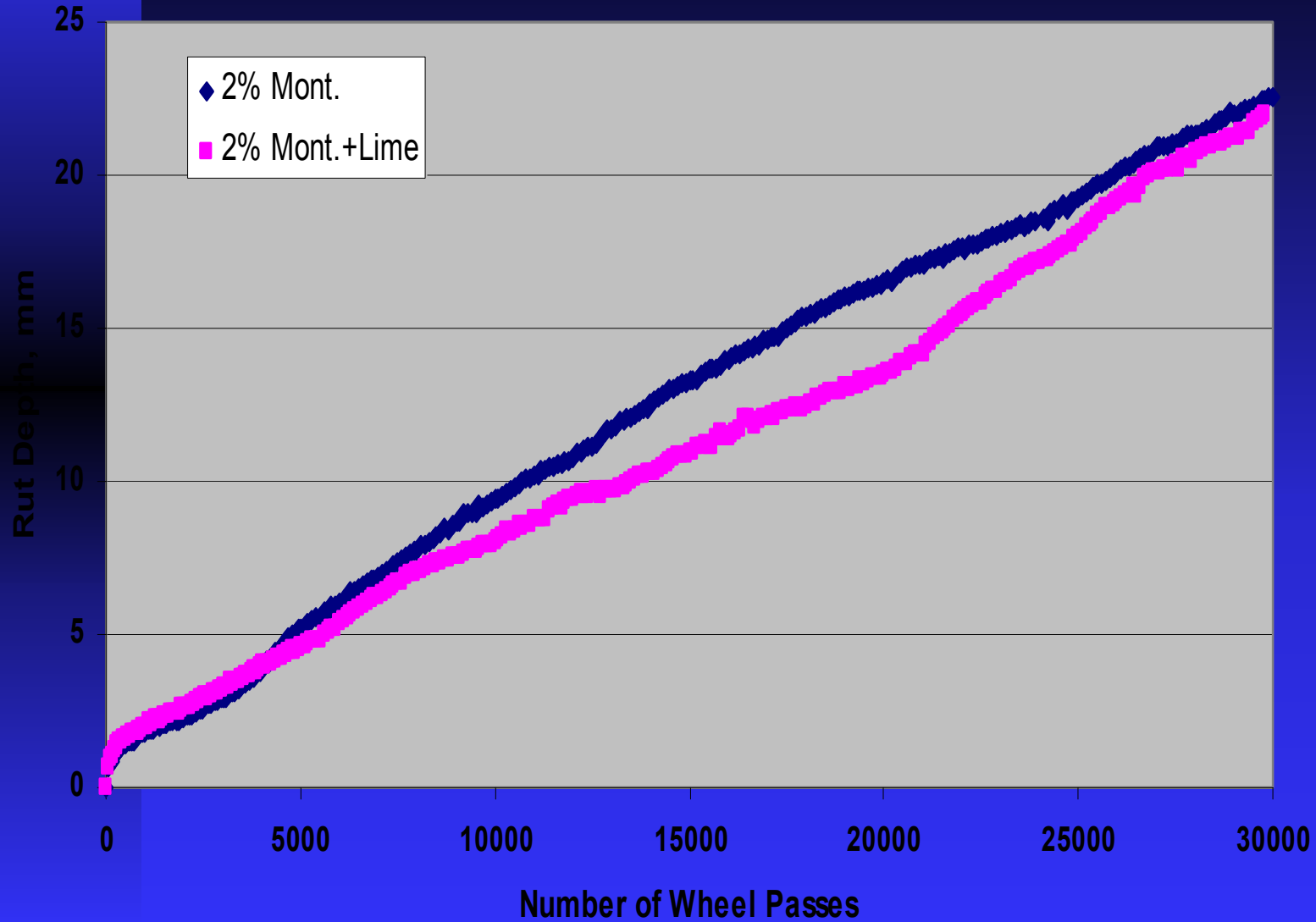
# Methylene Blue Testing of Diabase Doped with Clay



## Effect of Clay Type on HWT Results



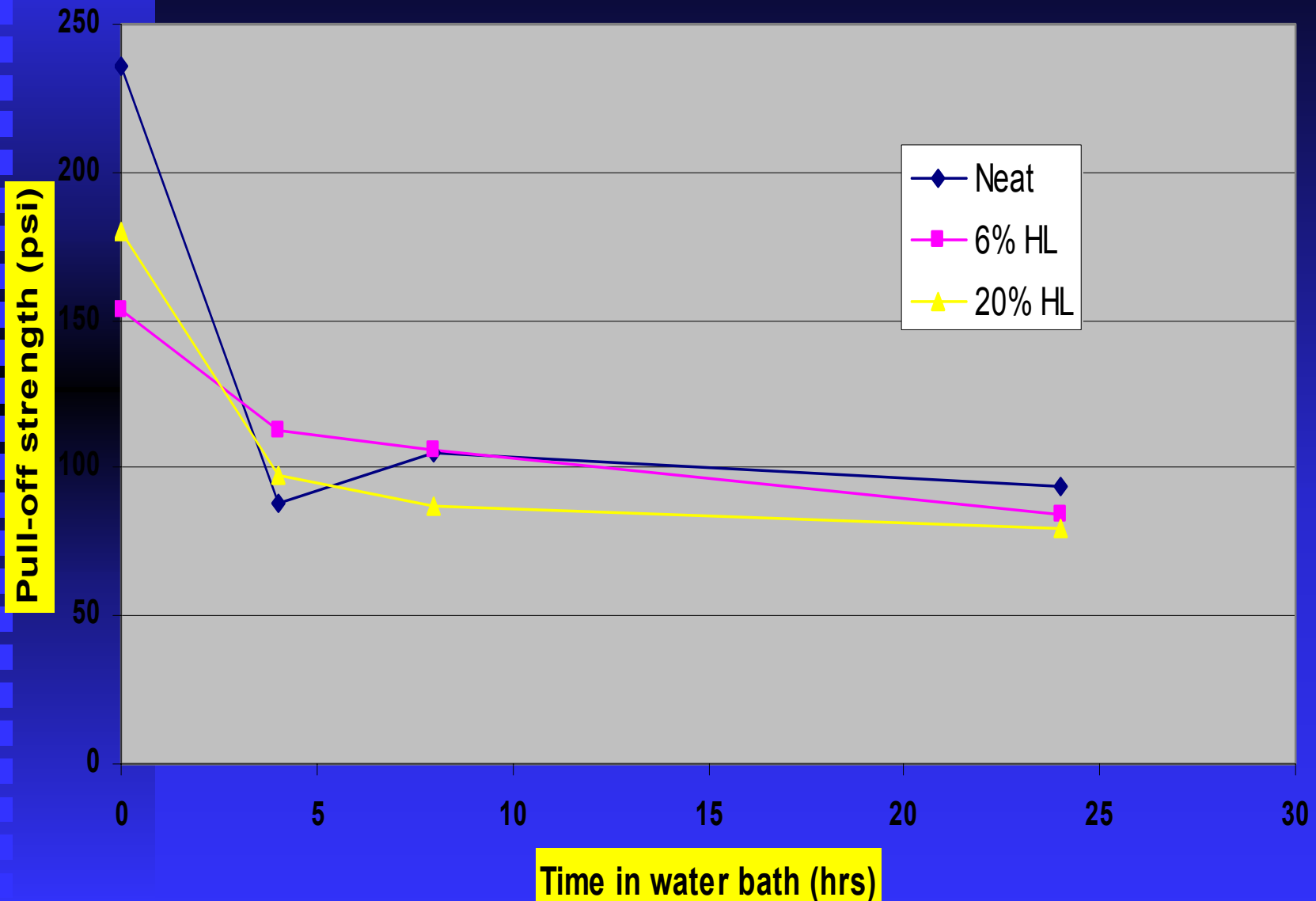
## Effect of Lime on Mitigating Moisture Damage



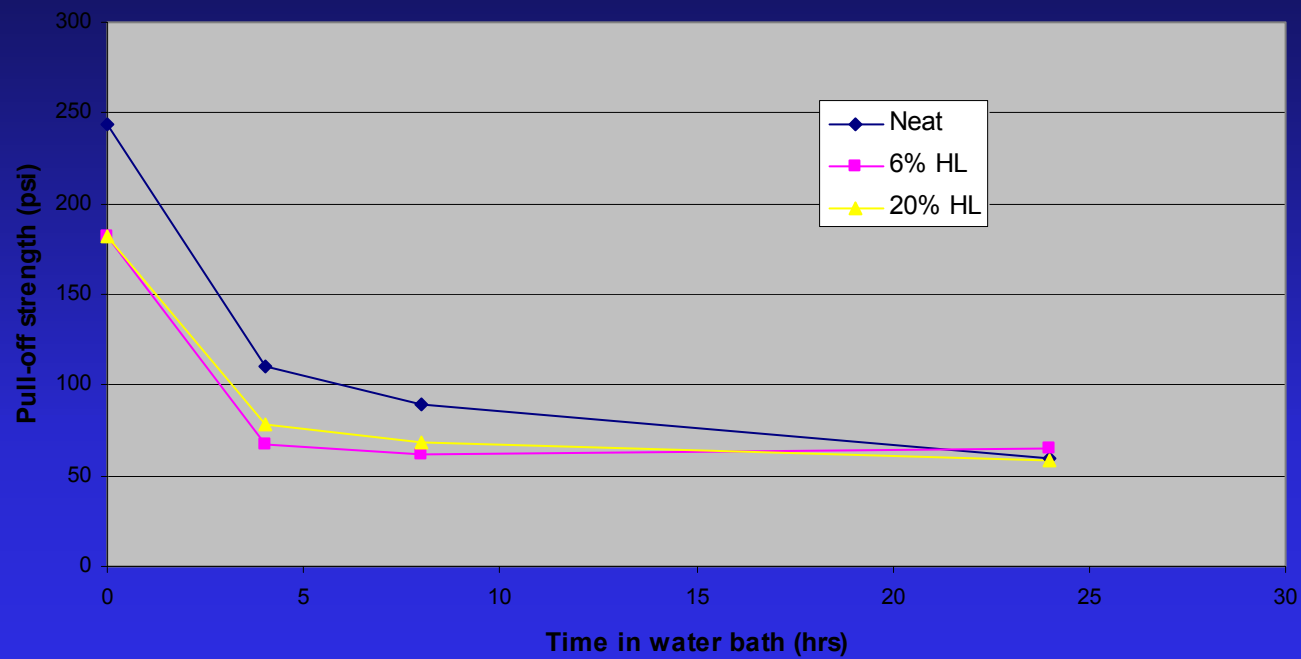


# Effect(s) Of Lime

# Elvaloy + 6% and 20% Hydrated Lime (ALF)



### SBS-Ig + 6% and 20% Hydrated Lime



# CONCLUSIONS

- Pneumatic Pull-Off Test is a quick, economical method for evaluating the moisture sensitivity of asphalt binders.
- Reproducibility of the test is quite good.
- Empirical model was developed that fits data for neat asphalts.
- High asphaltene asphalts are more sensitive to water than low asphaltene asphalts.

# Pitfalls

- Interpretation of aging effects and stiff binder (PG 76+) results.
- Relating lab findings with field performance
- Results limited to set film thickness and testing rate



PERFORMANCE	ISSUE	TEST	PARAMETER	When to Use
TENTATIVE MOISTURE SENSITIVITY TOOLS				
Raveling	Dissolution of Aggregate	Atomic Absorption	Na+, K+ Ion Concentration	Per Project
Stripping	Presence of Surfactants	Branthaver Separation Funnel Test	Presence of Emulsion	Binder Source
Rutting	Water Permeation	Pull-Off Test	Strength Ratio	Binder Source
Fatigue	Wet Oxidation	PAV	Rheological	Binder Source
Fatigue	Loss of Adhesion	?	Tackiness	Binder Source

PERFORMANCE	ISSUE	TEST	PARAMETER	When to Use
Tentative Moisture Sensitivity Tools				
Stripping	Adhesion		Surface Energy	Binder-Aggregate Pairing
Stripping	Adhesion	Sonic Bath Loose Mix	Gravimetric	Binder-Aggregate Pairing
Stripping	Adhesion	Pull-Off Testing of Mastics	Strength Ratio	Binder-Aggregate Pairing
Moisture Damage	ALL	Sonic Bath Sections of Cores	Gravimetric	Test Gyratory Cores or Field Samples